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(54) **APPARATUS FOR MANUFACTURING A FLANGED COMPOSITE COMPONENT AND METHODS OF MANUFACTURING THE SAME**

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(Continued)

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USPC 264/516, 520, 521, 523, 529, 259, 260, 264/573; 285/21.1, 285.11, 286.2, 290.1, 285/290.3, 382, 382.1, 382.4, 382.7, 405
See application file for complete search history.

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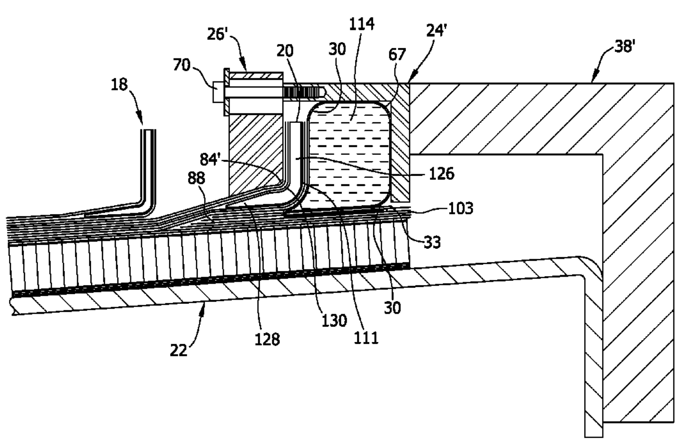
(57) **ABSTRACT**

A method of manufacturing a flanged composite component is provided. The method includes coupling a composite structure to s first composite material. The method includes coupling a second composite material to the composite structure and placing a first expansion device within the composite structure. A forming element is coupled to at least one of the first composite material, the composite structure, and the second composite material against the mold. The method includes coupling a pressure element to the forming element to define a space among the mold, the forming element, and the pressure element. The method includes expanding the first expansion device to impart a force to the second composite material to move the second composite material away from the composite structure and into the space to facilitate forming a first flange.

20 Claims, 8 Drawing Sheets



(51) **Int. Cl.**

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B29C 70/22	(2006.01)
B29C 67/00	(2006.01)
B29C 70/76	(2006.01)
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(52) **U.S. Cl.**

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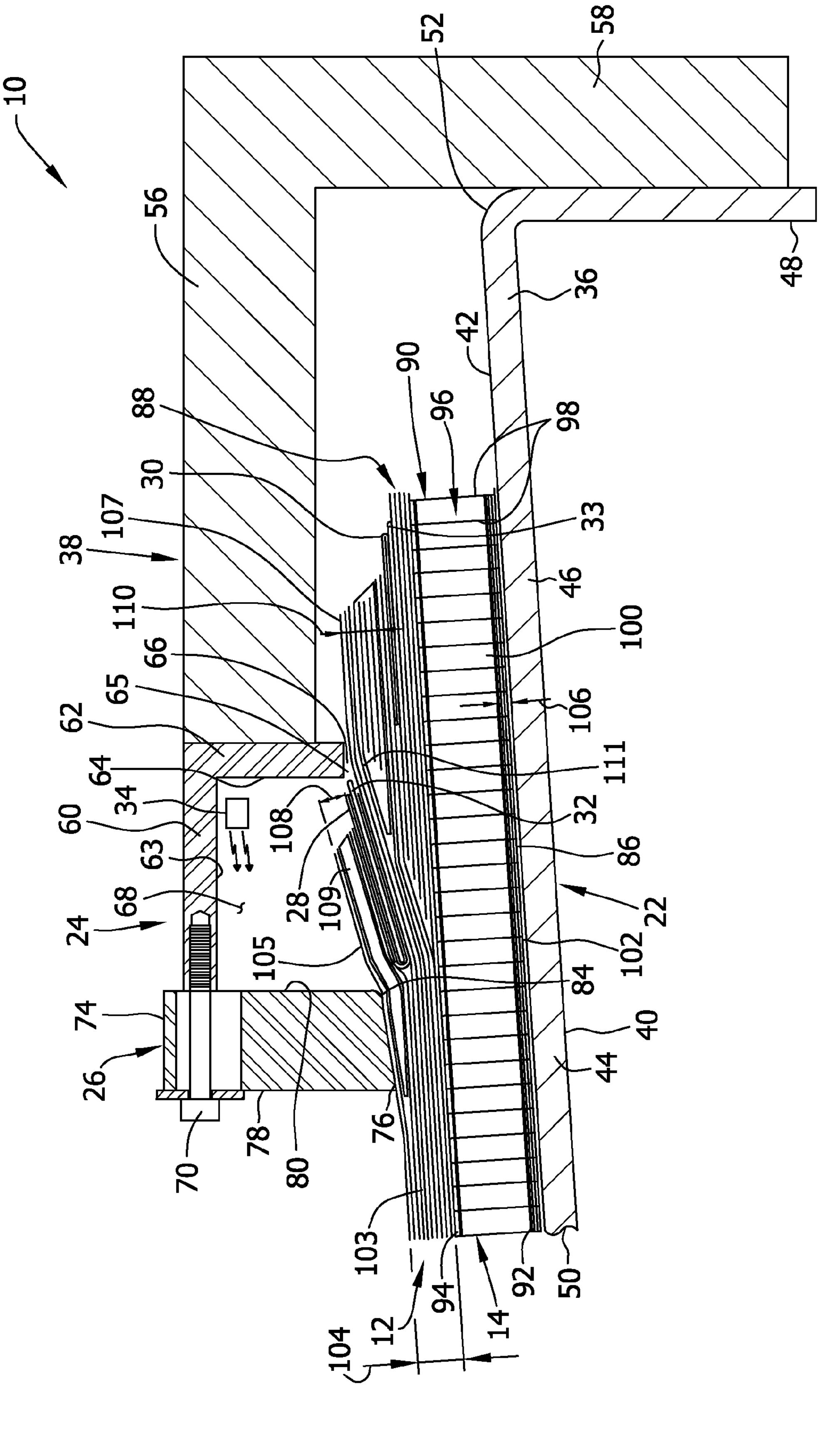
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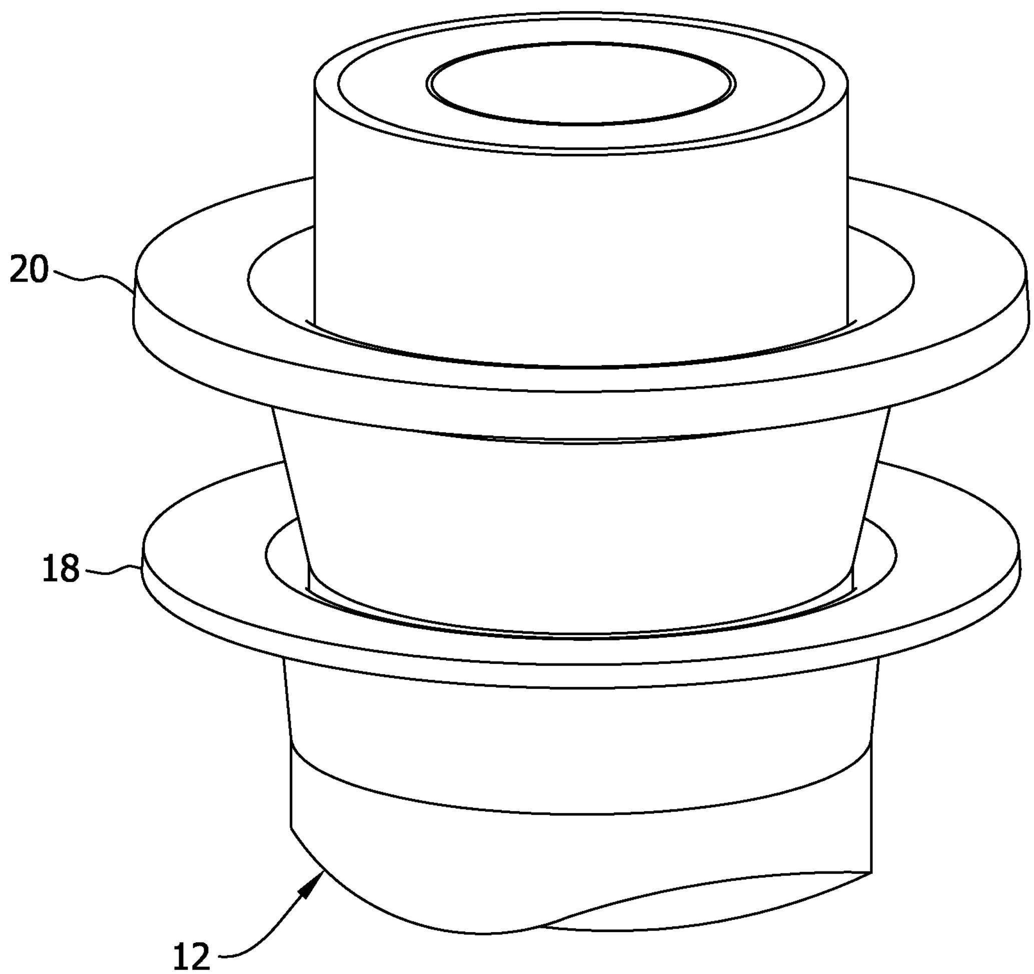
FIG. 1

FIG. 2



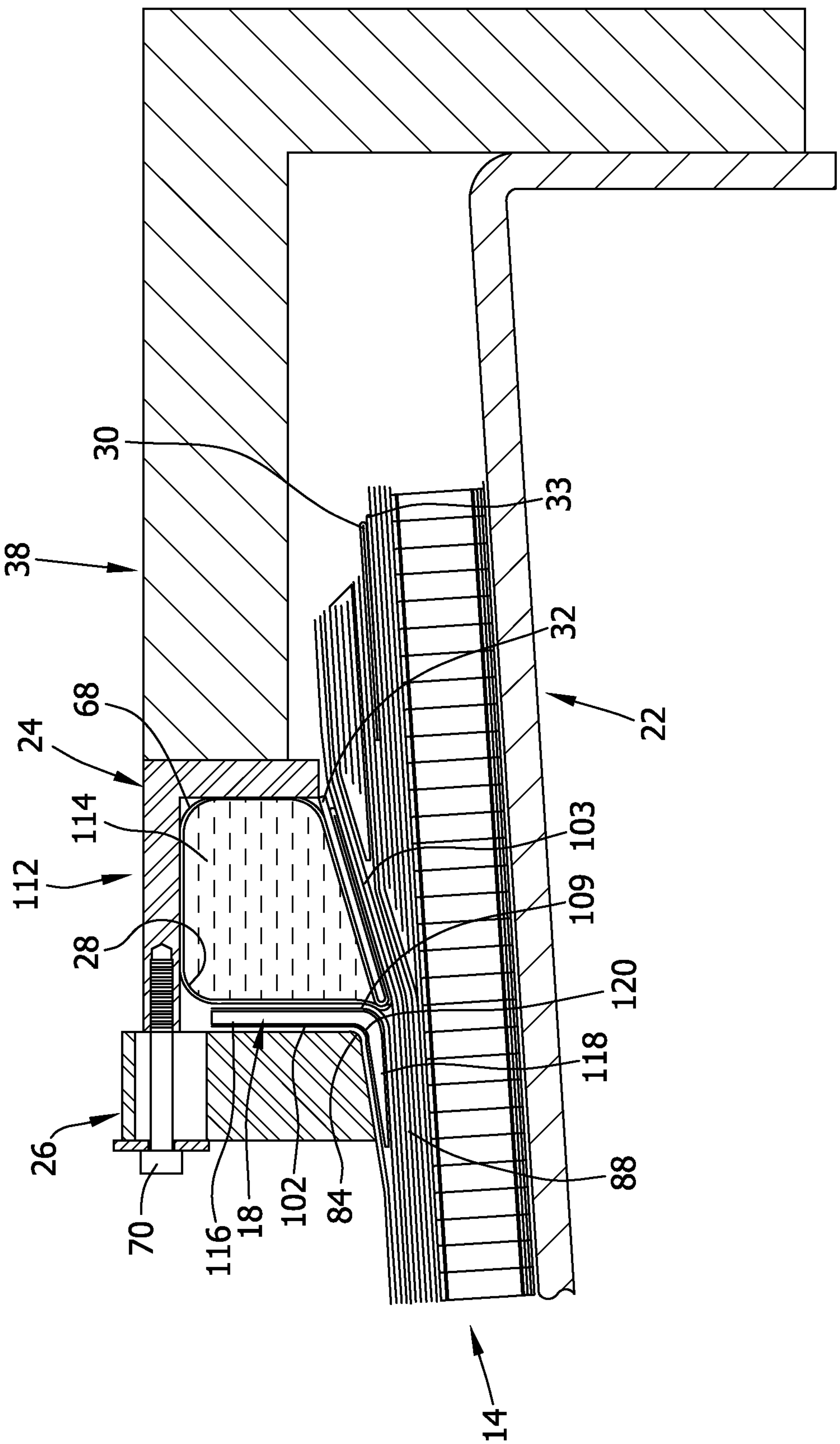

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FIG. 3

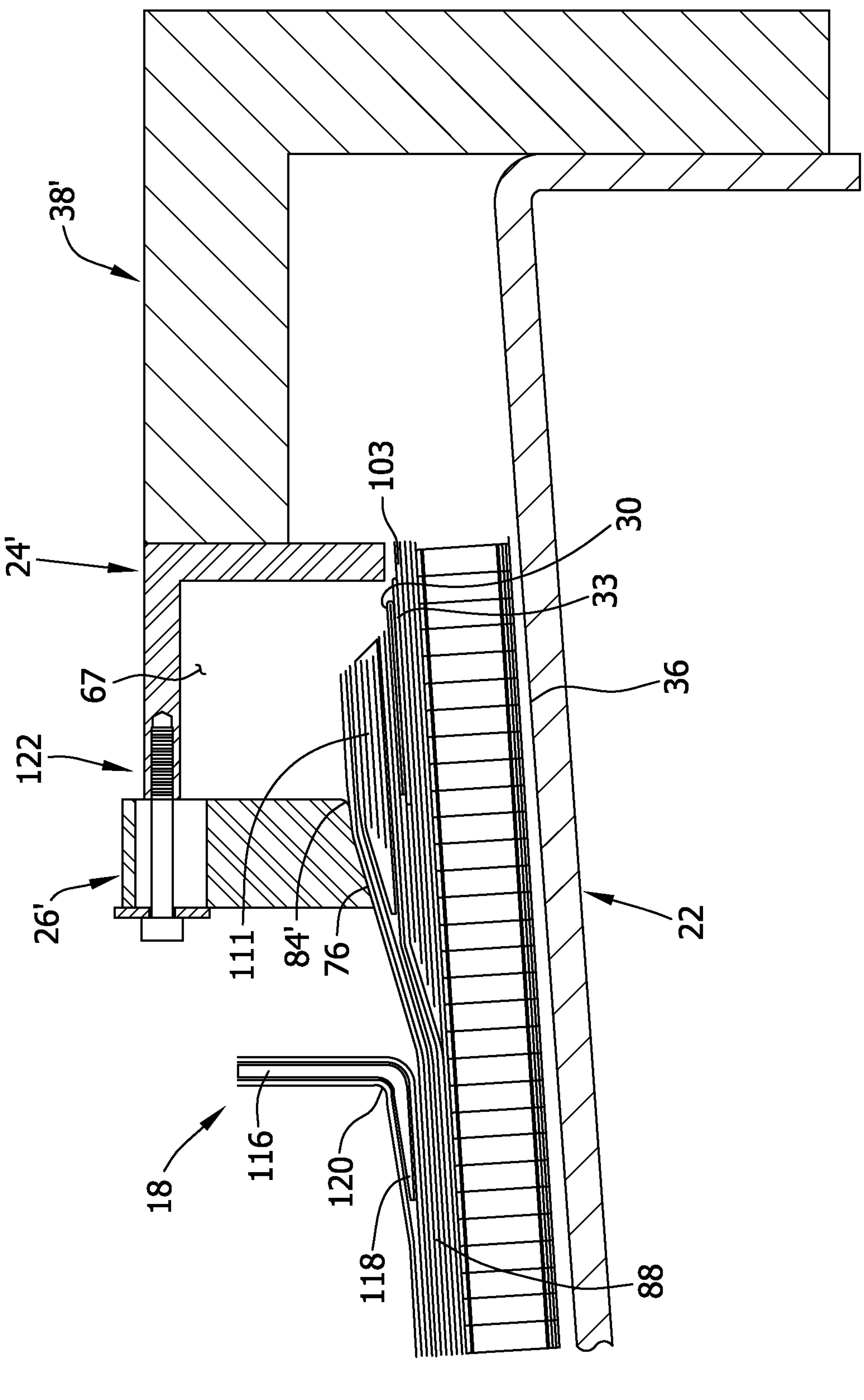


FIG. 4

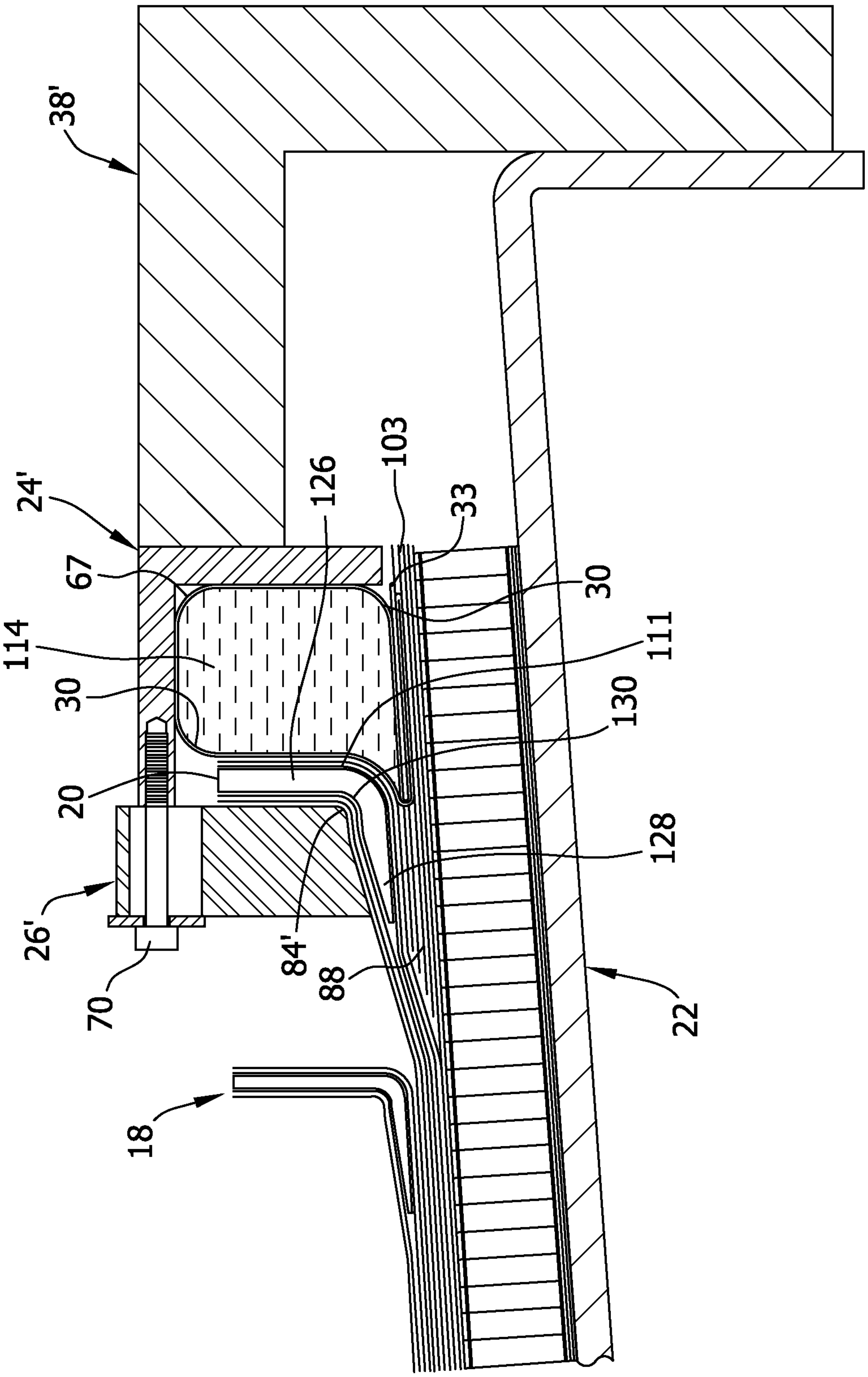


FIG. 5

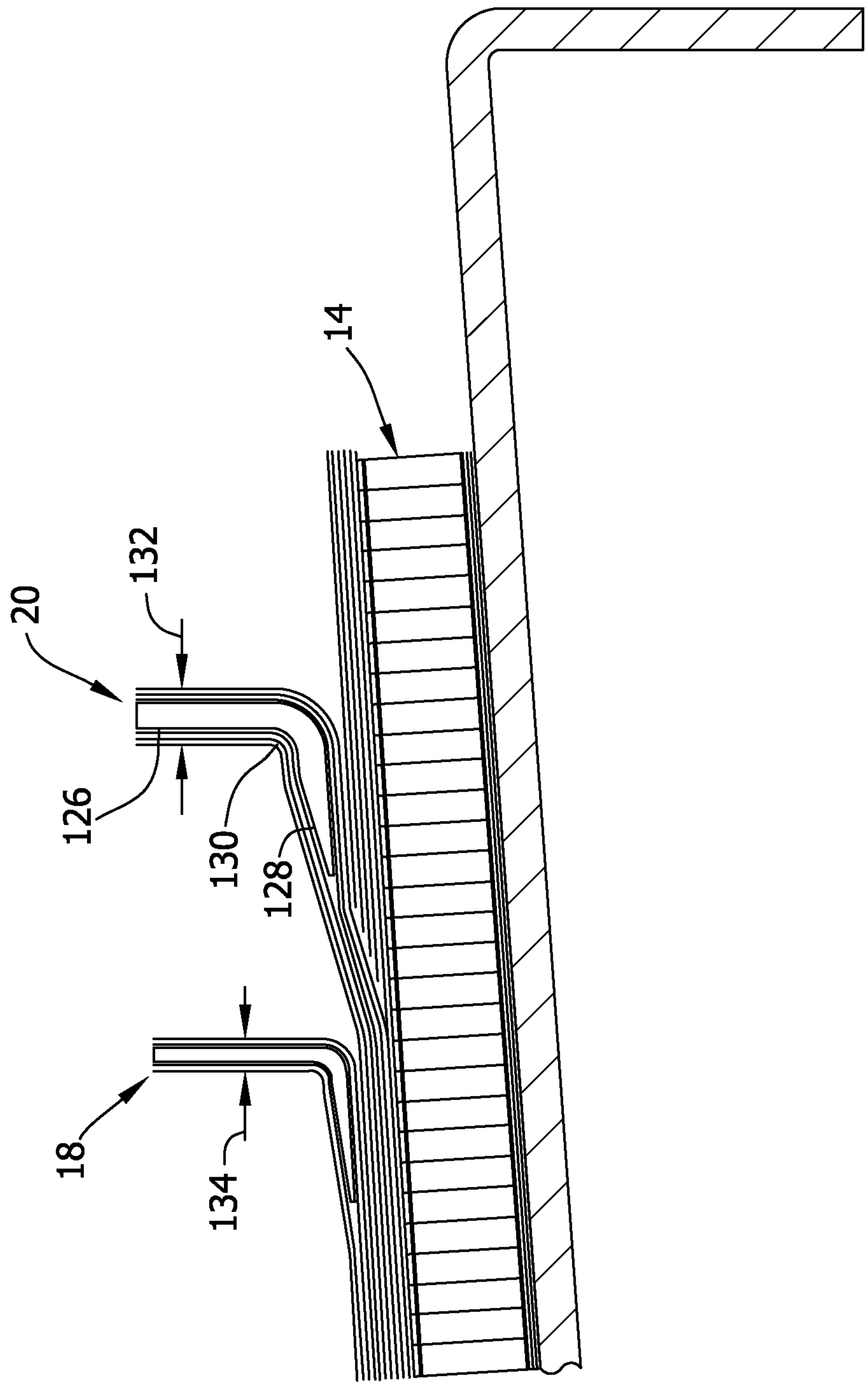
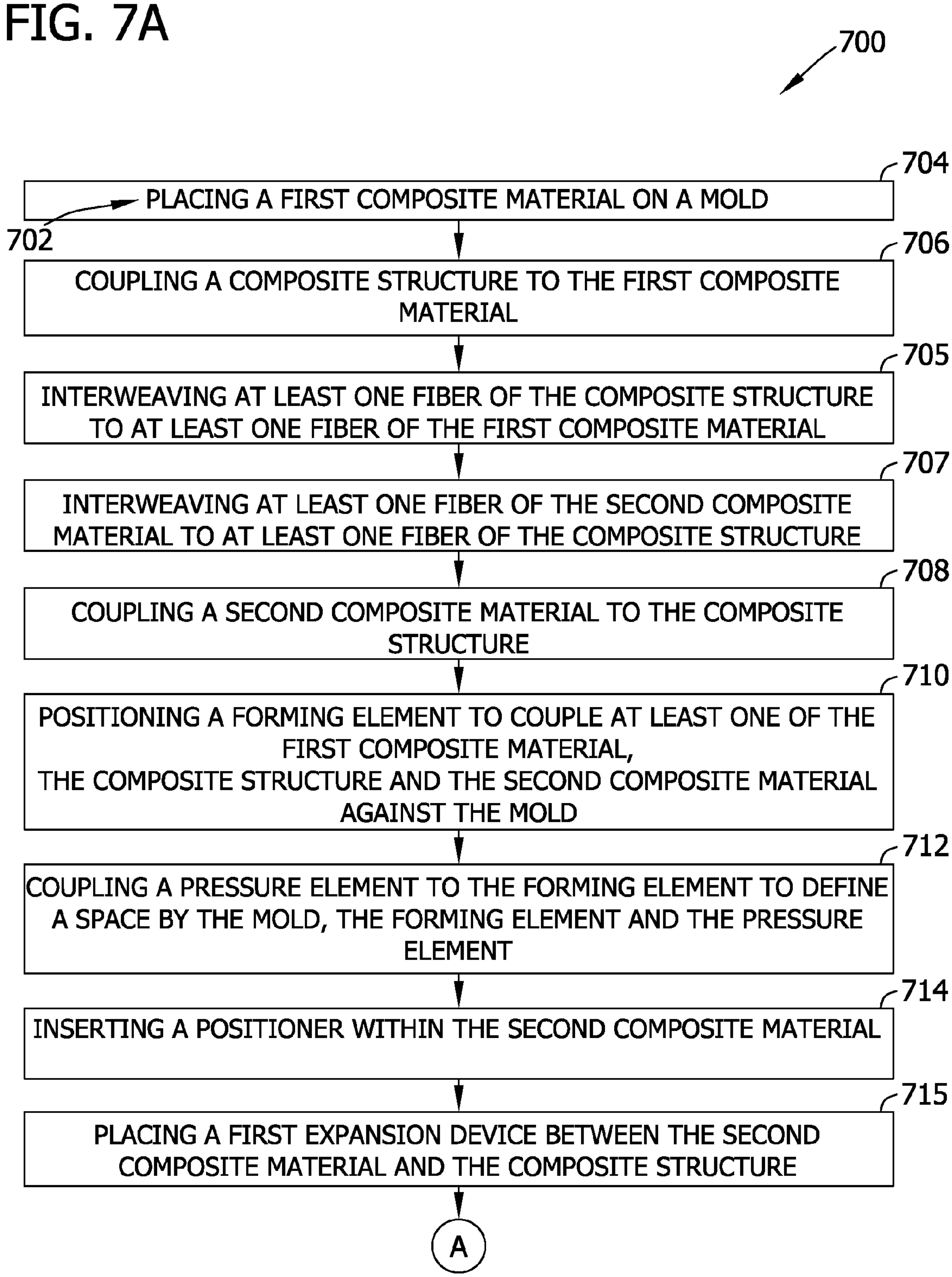


FIG. 6

FIG. 7A


700
704
PLACING A FIRST COMPOSITE MATERIAL ON A MOLD
702
706
COUPLING A COMPOSITE STRUCTURE TO THE FIRST COMPOSITE MATERIAL
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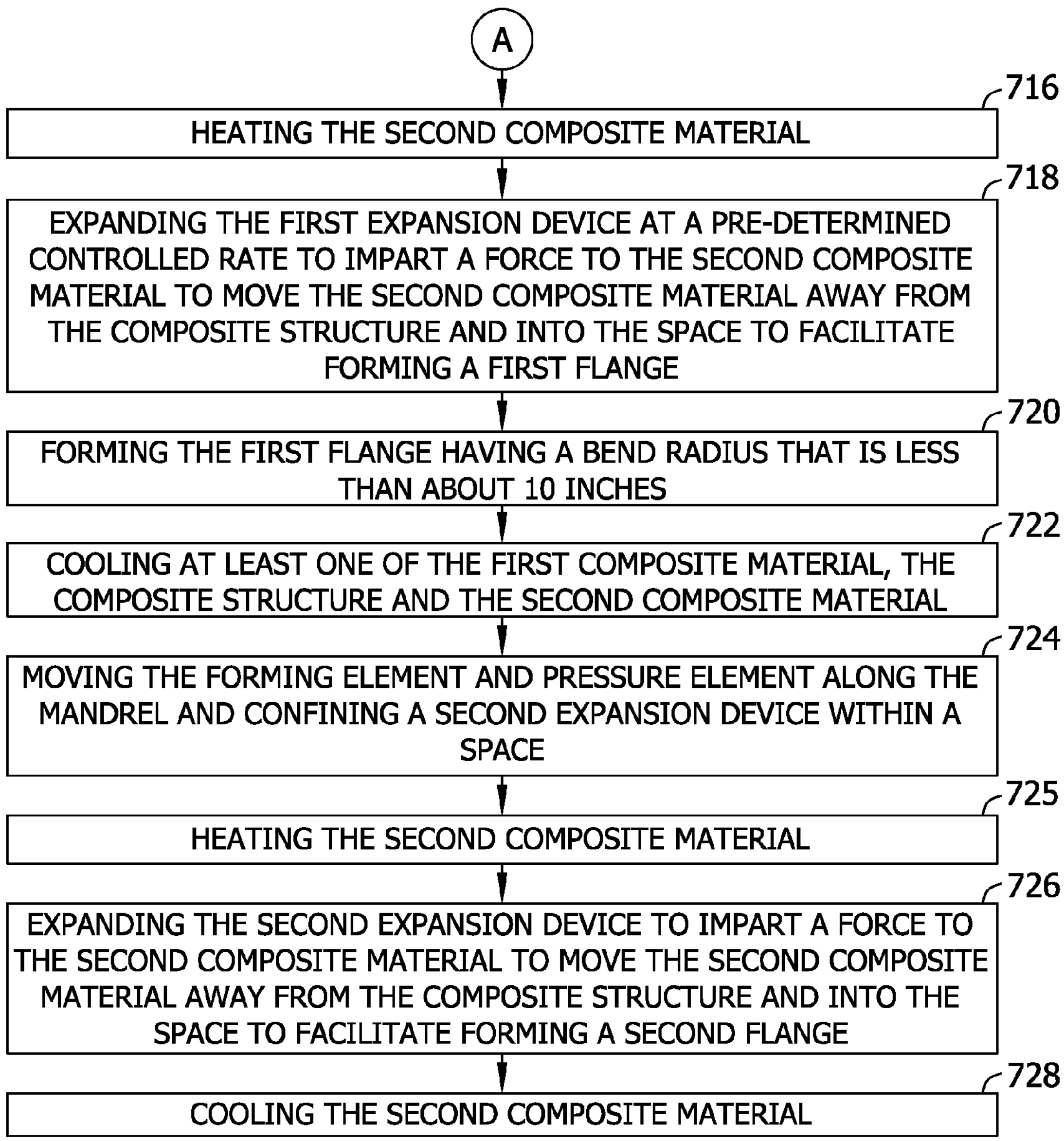
INTERWEAVING AT LEAST ONE FIBER OF THE COMPOSITE STRUCTURE TO AT LEAST ONE FIBER OF THE FIRST COMPOSITE MATERIAL
707
INTERWEAVING AT LEAST ONE FIBER OF THE SECOND COMPOSITE MATERIAL TO AT LEAST ONE FIBER OF THE COMPOSITE STRUCTURE
708
COUPLING A SECOND COMPOSITE MATERIAL TO THE COMPOSITE STRUCTURE
710
POSITIONING A FORMING ELEMENT TO COUPLE AT LEAST ONE OF THE FIRST COMPOSITE MATERIAL, THE COMPOSITE STRUCTURE AND THE SECOND COMPOSITE MATERIAL AGAINST THE MOLD
712
COUPLING A PRESSURE ELEMENT TO THE FORMING ELEMENT TO DEFINE A SPACE BY THE MOLD, THE FORMING ELEMENT AND THE PRESSURE ELEMENT
714
INSERTING A POSITIONER WITHIN THE SECOND COMPOSITE MATERIAL
715
PLACING A FIRST EXPANSION DEVICE BETWEEN THE SECOND COMPOSITE MATERIAL AND THE COMPOSITE STRUCTURE
A

FIG. 7B


A
716
HEATING THE SECOND COMPOSITE MATERIAL
718
EXPANDING THE FIRST EXPANSION DEVICE AT A PRE-DETERMINED CONTROLLED RATE TO IMPART A FORCE TO THE SECOND COMPOSITE MATERIAL TO MOVE THE SECOND COMPOSITE MATERIAL AWAY FROM THE COMPOSITE STRUCTURE AND INTO THE SPACE TO FACILITATE FORMING A FIRST FLANGE
720
FORMING THE FIRST FLANGE HAVING A BEND RADIUS THAT IS LESS THAN ABOUT 10 INCHES
722
COOLING AT LEAST ONE OF THE FIRST COMPOSITE MATERIAL, THE COMPOSITE STRUCTURE AND THE SECOND COMPOSITE MATERIAL
724
MOVING THE FORMING ELEMENT AND PRESSURE ELEMENT ALONG THE MANDREL AND CONFINING A SECOND EXPANSION DEVICE WITHIN A SPACE
725
HEATING THE SECOND COMPOSITE MATERIAL
726
EXPANDING THE SECOND EXPANSION DEVICE TO IMPART A FORCE TO THE SECOND COMPOSITE MATERIAL TO MOVE THE SECOND COMPOSITE MATERIAL AWAY FROM THE COMPOSITE STRUCTURE AND INTO THE SPACE TO FACILITATE FORMING A SECOND FLANGE
728
COOLING THE SECOND COMPOSITE MATERIAL

APPARATUS FOR MANUFACTURING A FLANGED COMPOSITE COMPONENT AND METHODS OF MANUFACTURING THE SAME

BACKGROUND OF THE INVENTION

The embodiments described herein relate generally to an apparatus for manufacturing a component, and more particularly, to methods and systems for manufacturing a flanged composite components.

Components often have flanges to increase the stiffness thereof and/or to facilitate assembly with other parts. Some conventional processes have been implemented to form flanges on components. In some known processes, flanges include separate metallic pieces that are bolted in position.

Composite components have been used in a variety of fields, such as the aerospace industry. Some processes deposit composite materials in a cylindrical configuration to form tubular composite components. However, current processes for forming flanges on composite components are labor intensive, and the quality of the flanges can be operator-dependent. Conventionally, operators sequentially stack composite materials in the flanged configuration by hand, which can be a slower process than laying up in the cylindrical configuration.

Moreover, it can be slow and difficult to lay up flanges from composite materials automatically or semi-automatically due to inherent machine limitations such as roller dimensions, the complexity of the motions and the intricacy of the manipulation during material placement of composite materials. More particularly, difficulties are encountered during use of current machines and tools to fabricate small bends or angles within the composite materials. Known machines and tools can be limited to fabricating flanges having large fillet bends, commonly 10 inches or larger for the bend radii of flanges, which can be impractical for some applications.

BRIEF DESCRIPTION OF THE INVENTION

In one aspect, a method of manufacturing a flanged composite component is provided. The method includes coupling a composite structure to a first composite material. The method includes coupling a second composite material to the composite structure and placing a first expansion device within the composite structure. A forming element is coupled to at least one of the first composite material, the composite structure, and the second composite material against the mold. The method includes coupling a pressure element to the forming element to define a space among the mold, the forming element, and the pressure element. The method includes expanding the first expansion device to impart a force to the second composite material to move the second composite material away from the composite structure and into the space to facilitate forming a first flange.

In another aspect, a composite component is provided. The composite component includes a first composite material and a composite structure coupled to the first composite material. A second composite material is coupled to the composite structure. The second composite material includes a flange integrally coupled to the composite structure and is positioned substantially orthogonal with respect to the composite structure. The flange includes an interface having a bend radius that is less than about 10 inches.

In yet another aspect, an apparatus for manufacturing a flanged composite component is provided. The apparatus includes a mold configured to couple to a composite material and includes a forming element coupled to the mold. A pressure element is coupled to the forming element to define a space among the mold, the forming element, and the pressure element. The apparatus includes a expansion device coupled to the mold and disposed within the space, wherein the expansion device is configured to impart a forming force to the forming element and the pressure element. A positioner is disposed within the composite material and in contact with the expansion device and configured to facilitate positioning the expansion device within the space.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a side cross sectional view of an exemplary component forming apparatus having a mold, a forming element, a pressure element, and an expansion device, and illustrates a composite material coupled to the mold.

FIG. **2** illustrates a front perspective view of a flanged component formed by the exemplary apparatus shown in FIG. **1**.

FIG. **3** illustrates a side cross sectional view of the exemplary mold, forming element, pressure element, and expansion device in a position for forming an exemplary flange from the composite material.

FIG. **4** illustrates a side cross sectional view of the exemplary mold, another forming element, another pressure element and another expansion device, and illustrates an exemplary formed flange.

FIG. **5** illustrates a side cross sectional view of the exemplary mold, forming element, pressure element and expansion device shown in FIG. **4** for forming another exemplary flange from the composite material.

FIG. **6** illustrates a side cross sectional view of exemplary flanges formed from the composite material.

FIG. **7** illustrates an exemplary flowchart illustrating a method of manufacturing a flanged component.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** illustrates a side cross sectional view of an exemplary component forming apparatus **10**. FIG. **2** illustrates a front perspective view of a flanged component **12** formed by apparatus **10** shown in FIG. **1**. Component **12** includes a composite material **14** having a first flange **18** and a second flange **20**. Alternatively, fewer than two flanges or more than two flanges can be used to enable component **12** to function as described herein. Flanges **18**, **20** are formed from and integrally coupled to composite material **14** (shown in FIG. **1**).

In one embodiment, apparatus **10** includes a mold **22**, a forming element **24**, a pressure element **26**, a first expansion device **28**, and a second expansion device **30**. Moreover, apparatus **10** includes a first positioner element **32** that is coupled to first expansion device **28** and a second positioner **33** that is coupled to second expansion device **30** and includes a temperature control device **34** which is configured to heat a space **68** and composite material **14** having a thickness **108**.

Mold **22** includes a mandrel **36** and a support element **38**. Mandrel **36** is configured to support composite material **14** and support element **38** is configured to support mandrel **36** during component formation as will be discussed. In one embodiment, mandrel **36** and support element **38** are annular shaped and are formed from a variety of materials such as, but not limited to, metals and metal alloys having predetermined stiffnesses. Alternatively, mandrel **36** and support element **38** can have any shape and material composition that enables apparatus **10** to function as described herein.

In one embodiment, mandrel **36** includes a first side **40**, a second side **42**, and a surface **44** between first and second sides **40** and **42**. Mandrel **36** further includes a first portion **46** and second portion **48** which are positioned substantially orthogonal with respect to each other. Moreover, first portion **46** includes a first end **50** and a second end **52**. First end **50** is angled with respect to second end **52**. Temperature control device **34** is configured to apply heat to space **68** and to heat composite material **14** having thickness **108** and/or to remove heat from composite material **14**. In one embodiment, temperature control device **34** is configured to direct heated forced air onto composite material **14**. Alternatively, any type of temperature control device can be used to heat and/or cool to enable apparatus **10** to function as described herein.

Support element **38** includes a first portion **56** and a second portion **58**. Second portion **58** is coupled to mandrel second portion **48** and extends beyond mandrel second portion **48** such that support element **38** is configured to react to forming forces generated during component formation. In one embodiment, support element **38** includes an annular ring shape. Alternatively, support element **38** may include a disk shape. Support element **38** may have any shape that enables apparatus **10** to function as described herein.

Forming element **24** is configured to contain at least one first and second expansion devices **28** and **30** during component formation. Forming element **24** includes a first portion **60** and a second portion **62** which are positioned substantially orthogonal with respect to each other. Each portion **60** and **62** has a respective side **63** and **64** orientated toward mandrel **36**. In one embodiment, first portion **60** is coupled to pressure element **26** and second portion **62** is coupled to support element **38**. Second portion **62** includes a bottom **65** that is spaced away from mandrel **36** to define an opening **66** between second portion **62** and mandrel **36**. In addition, space **68** is defined by at least mold **22**, forming element **24**, and pressure element **26**.

Pressure element **26** is coupled to forming element **24** and configured to apply pressure to at least one of first and second expansion devices **28** and **30** during component formation. More particularly, in an embodiment, pressure element **26** is adjustably coupled to forming element **24** by a fastener **70**. In one embodiment, fastener **70** includes an adjustable screw. Alternatively, any adjusting mechanism that enables pressure element **26** to couple to forming element **24** can be used that enables apparatus **10** to function as described.

Pressure element **26** includes a top **74**, a bottom **76**, a first side **78**, and a second side **80**. Pressure element **26** further includes a curvilinear end **84** between bottom **76** and second side **80**. In one embodiment, curvilinear end **84** is configured as a convex curve to facilitate curving outward towards space **68**. Further, in one embodiment, curvilinear end **84** includes a bend radius that is less than about 10 inches. Alternatively, curvilinear end **84** may include a bend radius that is more than about 10 inches. Moreover, in one embodiment, curvilinear end **84** includes a bend radius that is between about 1 inch and about 5 inches. Further, in one embodiment, curvilinear end **84** includes a bend radius that is less than about 1 inch.

Each expansion device **28** and **30** includes a flexible material such as, but not limited to, butyl materials, silicone rubber, fluoro-elastomers, and nylon bagging films. In an embodiment, expansion devices **28** and **30** include a bladder. Moreover, expansion devices **28** and **30** include a valve (not shown) that is configured to pass a substance (not shown) into expansion devices **28** and **30** for inflation. The valve is coupled to a source (not shown) to facilitate delivering substance into expansion devices **28** and **30**. The substance may include a compressible and/or incompressible fluid such as, for example, air or water. Moreover, positioner **32** is in contact with first expansion device **28** and second positioner **33** is in contact with second expansion device **30**. First positioner **32** is configured to facilitate positioning first expansion device **28** during component formation and second positioner **33** is configured to facilitate positioning second expansion device **30** during component formation.

Composite material **14** is coupled to mandrel **36**. Composite material **14** includes a material having two or more constituent materials with different physical and/or chemical properties. In one embodiment, composite material **14** includes a matrix material (not shown) and a reinforcement material (not shown). The matrix material surrounds and supports the reinforcement material, and may include metal and/or non-metal materials. Non-metal material includes materials such as, but not limited to, polyester resin, acrylic resin, vinyl ester resin, epoxy resin, polyurethane resin, phenolic resin, polyamide resin, and mixtures thereof. The reinforcement material imparts mechanical and physical properties to enhance the matrix material properties. Reinforcement material includes structures such as, for example, fibers or plies. Fiber includes material such as, but not limited to, glass fiber, graphite fiber, carbon fiber, ceramic fiber, aromatic polyamide fiber, and mixtures thereof. One or more fibers may be pre-impregnated with the one or more resins prior to be deposited or placed on mandrel **36**.

Composite material **14** includes a first composite material **86**, a second composite material **88**, and a composite structure **90**. Composite structure **90** is coupled to first composite material **86** and to second composite material **88**. In one embodiment, composite structure **90** includes a first layer of fibers **92**, a second layer of fibers **94**, and a honeycomb structure **96**. Honeycomb structure **96** is coupled to and positioned between first and second fiber layers **92** and **94**. Honeycomb structure **96** includes a plurality of walls **98** defining cells **100** within structure **96**. In one embodiment, composite structure **90** is coupled to first composite material **86** by interweaving first composite material **86** with first layer of fibers **92**. Moreover, composite structure **90** is coupled to second composite material **88** by interweaving second composite material **88** with second layer of fibers **94**. Alternatively, any coupling mechanism can be used to join composite structure **90** to first and second composite materials **86** and **88**.

First composite material **86** includes a plurality of fibers **102** and second composite material **88** includes a plurality of fibers **103**. In one embodiment, fibers **102** and **103** include the same material composition. Alternatively, fibers **102** of first composite material **86** can have a different material composition than fibers **103** of second composite material **88**. In one embodiment, second composite material **88** includes a higher number of fibers **103** and a greater thickness **104** than a number of fibers **102** and a thickness **106** of first composite material **86**. Thicknesses **104** and **106** of first composite material **86** and second composite material **88** are varied to produce components **14** having varied physical properties. Alternatively, the number of fibers **102** and thickness **106** of first composite material **86** can be the same as or greater than the number of fibers **103** and thickness **106** of second composite material **88**.

In one embodiment, first composite material **86** is coupled to mandrel second side **42**. First composite material **86** may be deposited on second side **42** using any variety of techniques (not shown) such as, for example, tape placement, fiber placement, and/or hand or automatic lay up. Composite structure **90** is configured to extend away from mandrel **36** and towards space **68**. Moreover, second composite material

88 is deposited between forming element 24 and mandrel 36 and between pressure element 26 and mandrel 36.

Expansion devices 28 and 30 are inserted within fibers 103 and first and second positioners 32 and 33 are positioned within a portion of fibers 103. First expansion device 28 is positioned within second composite material 88 such that thickness 108 of fibers 103 between first expansion device 28 and a top layer 105 of fibers 103 is less than a thickness 110 of fibers 103 between second expansion device 30 and a top layer 107 of fibers 103. Thicknesses 108 and 110 of fibers 103 are varied to produce flanges 18 and 20 having varied sizes. Alternatively, thicknesses 108 and 110 of fibers 103 can be substantially the same to produce flanges 18 and 20 with similar sizes. First expansion device 28, in a deflated state, is configured to position a first portion 109 of fibers 103 of second composite material 88 into space 68 and toward curvilinear end 84 of pressure element 26. Second expansion device 30, in a deflated state, is configured to position a second portion 111 of fibers 103 of second composite material 88 within opening 66 and towards second portion 62 of forming element 24.

FIG. 3 illustrates a side cross sectional view of mold 22, forming element 24, pressure element 26, and first expansion device 28 in a position 112 for forming first flange 18 from composite material 14. First expansion device 28 is shown in an inflated state with substance 114 delivered into first expansion device 28 through the valve (not shown) to inflate first expansion device 28. In one embodiment, first expansion device 28 is inflated at a predetermined, controlled rate to facilitate minimizing and/or eliminating local laminate deformations (not shown) to second composite material 88. While inflated, first expansion device 28 is confined in space 68 by at least one of forming element 24, pressure element 26 and first positioner 32.

Support element 38 is configured to react to inflation of expansion device 28 and apply a force to resist movement of forming element 24. Similarly, fastener 70 is configured to react to inflation of expansion device 28 and apply a force to resist movement of pressure element 26. First expansion device 28 is configured to impart a forming force against the first portion 109 of fibers 103 of second composite material 88. More particularly, first expansion device 28 is configured to controllably bend fibers 103 about curvilinear end 84 to form first flange 18. In one embodiment, first flange 18 is formed having a first portion 116, a second portion 118, and an interface 120 therebetween. First portion 116 is positioned substantially orthogonal to second portion 118 and interface 120 includes a bend radius that is less than about 10 inches. In one embodiment, interface 120 includes bend radius between about 1 inch to about 5 inches. Alternatively, interface 120 may include a bend radius that is more than about 10 inches. Moreover, in one embodiment, interface 120 includes a bend radius that is between about 1 inch and about 5 inches. Further, in one embodiment, interface 120 includes a bend radius that is less than about 1 inch.

FIG. 4 illustrates a side cross sectional view of mold 22, another forming element 24', another pressure element 26' and another support element 38' in another position 122 along mold 22 and illustrates first flange 18, with first expansion device 28 and first positioner 32 removed. Forming element 24', pressure element 26' and forming element 38' are similar to respective forming element 24, pressure element 26 and forming element 38 (shown in FIG. 1). In the exemplary embodiment, forming element 24', pressure element 26' and forming element 38' are sized differently than corresponding forming element 24, pressure 3element 26 and forming element 38 (shown in FIG. 1) to facilitate compensating for new position 122 along mold 22. More particularly, forming element 24, pressure element 26 and forming element 38 (shown in FIG. 1) are removed from mold 22 and forming element 24', pressure element 26' and forming element 38' are adjustably coupled to one another and to mold 22. Moreover, curved end 84' of pressure element 26' is also sized differently than corresponding curved end 84 (shown in FIG. 1). Alternatively, curved end 84' may be similarly sized as curved end 84 (shown in FIG. 1).

First flange 18 is shown as integrally formed from and coupled to second composite material 88. Forming element 24' and pressure element 26' are shown position 122 with respect to mandrel 36 and away from first flange 18. More particularly, second expansion device 30, positioner 33, and second portion 111 of fibers 103 are positioned within space 67. Moreover, bottom 76 and curvilinear end 84' of pressure element 26 are positioned to be in contact with fibers 103. Second expansion device 30, in a deflated position, positions second portion 111 of fibers 103 into space 67.

FIG. 5 illustrates a side cross sectional view of mold 22, forming element 24', pressure element 26' and support element 38' and second expansion device 30 for forming second flange 20 from composite material 88. Second expansion device 30 is shown in an inflated state with substance 114 delivered into second expansion device 30 through the valve (not shown) to inflate second expansion device 30. In one embodiment, second expansion device 30 is inflated at a predetermined controlled rate to facilitate minimizing and/or eliminating local laminate deformations (not shown) to second composite material 88. While inflated, second expansion device 30 is confined in space 67 by at least one of second positioner 33, forming element 24', pressure element 26' and support element 38'.

Support element 38' is configured to react to inflation of expansion device 30 and apply force to resist movement of forming element 24'. Similarly, fastener 70 is configured to react to inflation of expansion device 30 to apply a force to resist movement of pressure element 26'. Second expansion device 30 is configured to impart a forming force against second portion 111 of fibers 103. Expansion device 30 is configured to controllably bend second portion 111 of fibers 103 about curvilinear end 84' to facilitate forming second flange 20. More particularly, second flange 20 is formed having a first portion 126, a second portion 128, and an interface 130 therebetween. First portion 126 is positioned substantially orthogonal to second portion 128 and interface 130 includes a bend radius that is less than about 10 inches. In one embodiment, interface 130 includes a bend radius from about 1 inch to about 5 inches. Alternatively, interface 130 may include a bend radius that is more than about 10 inches. Moreover, in one embodiment, interface 130 includes a bend radius that is between about 1 inch and about 5 inches. Further, in one embodiment, interface 130 includes a bend radius that is less than about 1 inch.

FIG. 6 illustrates a side cross sectional view of flanges 18 and 20 formed from composite material 14. In one embodiment, second flange 20 has a thickness 132 that is different than a thickness 134 of first flange 18. In the exemplary embodiment, thickness 132 is greater than thickness 134. Alternatively, second flange 20 has a thinner thickness or substantially the same thickness as first flange 18. Varying the thicknesses of flanges 18 and 20 facilitates in providing different physical properties to component 12 (shown in FIG. 1).

FIG. 7 is an exemplary flowchart 700 illustrating a method 702 of manufacturing a flanged composite component, for example component 12 (shown in FIG. 2). Method 702 includes placing 704 a first composite material, such as first composite material **86** (shown in FIG. **1**), on a mold, for example mold **22** (shown in FIG. **1**). A composite structure, such as composite structure **90** (shown in FIG. **1**), is coupled **706** to the first composite material. Method **702** includes coupling **708** a second composite material, for example second composite material **88** (shown in FIG. **1**), to the composite structure. In one embodiment, coupling the composite structure to the first composite material includes interweaving **705** at least one fiber of the composite structure to at least one fiber of the first composite material and coupling the second composite material to the composite structure includes interweaving **707** at least one fiber of the second composite material to at least one fiber of the composite structure.

Method **702** further includes positioning **710** a forming element, for example forming element **24** (shown in FIG. **1**), to hold at least one of the first composite material, the composite structure and the second composite material. A pressure element, such as pressure element **26** (shown in FIG. **1**), is coupled **712** to the forming element to define a space, for example space **68** (shown in FIG. **1**), among at least the mold, the forming element, and the pressure element. Method **702** also includes inserting **714** a positioner, for example first positioner **32** (shown in FIG. **1**), within the second composite material. In addition, method **702** includes placing **715** a first expansion device, for example first expansion device **28** (shown in FIG. **1**), within the second composite material. The first positioner **32** is placed in contact with the first expansion device.

Method **702** further includes heating **716** the second composite material, for example second composite material **88**. In the exemplary method **702**, heating **716** the second composite material includes directing forced hot air toward second composite material. More particularly, forced hot air is directed to outer fibers, such as fiber portion **111** of second composite material. Heating **716** may include any type of heat addition to enable apparatus to function as described herein. Alternatively, heating **716** may include heating first composite material and/or composite structure. The first expansion device is controllably expanded **718** at a predetermined rate to impart a force to the second composite material to move the second composite material away from the composite structure and into the space to facilitate forming a first flange, such as first flange **18** (shown in FIG. **1**). Method **702** also includes forming **720** the first flange having a bend radius that is less than about 10 inches. Alternatively, method **702** may include manufacturing a bend radius for the first flange that is more than about 10 inches. Moreover, method **702** includes manufacturing a bend radius that is between about 1 inch and about 5 inches. Method **702**, in one embodiment, includes manufacturing a bend radius that is less than about 1 one. Method **702** includes cooling **722** the second composite material, for example second composite material **88**. In the exemplary method **702**, cooling **722** the second composite material includes directing forced air toward second composite material. More particularly, forced hot air is directed to outer fibers, such as outer fibers **107** of second composite material. Cooling **722** may include any type of heat removal to enable apparatus to function as described herein. Alternatively, cooling **722** may include cooling first composite material and/or composite structure.

Method **702** further includes moving **724** the forming element and the pressure element along the mandrel. A second expansion device, such as second expansion device **30** (shown in FIG. **1**), is confined within a space, for example space **67** (shown in FIG. **4**). Method **702** includes heating **725** the second composite material, for example second composite material **88** (shown in FIG. **5**). Moreover, method **702** includes heating a second portion of the fibers of the second composite m material, for example second portion **111** of fibers **103** (shown in FIG. **5**). Method **702** includes expanding **726** the second expansion device to impart a force to the second composite material to move the second composite material away from the composite structure and into the space to facilitate forming a second flange, such as second flange **20** (shown in FIG. **1**). Method **702** also includes forming the second flange having a bend radius that is less than about 10 inches. Alternatively, method **702** may include manufacturing a bend radius for the second flange that is more than about 10 inches. Method **702** includes cooling **728** the second composite material after expanding the second expansion device. Alternatively, method **702** may include cooling the first composite material and/or the composite structure.

A technical effect of the systems and methods described herein includes at least one of: a method of manufacturing a flanged composite component from a first composite material, a second composite material, and a composite structure; a flanged composite component; and an apparatus for manufacturing a flanged composite component.

Exemplary embodiments of an apparatus and methods for manufacturing flanged composite components are described above in detail. The methods and systems are not limited to the specific embodiments described herein, but rather, components of systems and/or steps of the methods may be utilized independently and separately from other components and/or steps described herein. For example, the methods may also be used in combination with other manufacturing systems and methods, and are not limited to practice with only the systems and methods as described herein. Rather, the exemplary embodiment can be implemented and utilized in connection with many other component formation applications.

Although specific features of various embodiments of the invention may be shown in some drawings and not in others, this is for convenience only. In accordance with the principles of the invention, any feature of a drawing may be referenced and/or claimed in combination with any feature of any other drawing.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

What is claimed is:

1. A method of manufacturing a flanged composite component, the method comprising:

coupling a composite structure to a first composite material;

coupling a second composite material to the composite structure;

placing a first expansion device within the second composite material;

coupling a forming element to the second composite material against a mold;

coupling a pressure element to the forming element to define a space among a mandrel of the mold, the forming element and the pressure element; and expanding the first expansion device to impart a force to the second composite material to move the second composite material away from the composite structure and into the space to facilitate forming, a first flange.

2. The method of claim **1**, further comprising inserting a positioner within the second composite material and in contact with the first expansion device.

3. The method of claim **1**, further comprising, heating, the second composite material prior to inflating the first expansion device.

4. The method of claim **1**, further comprising cooling the second composite material after inflating the first expansion device.

5. The method of claim **1**, wherein coupling the composite structure to the first composite material comprises interweaving at least one fiber of the composite structure to at least one fiber of the first composite material.

6. The method of claim **1**, wherein coupling the second composite material to the composite structure comprises interweaving at least one fiber of the second composite material to at least one fiber of the composite structure.

7. The method of claim **1**, wherein the first expansion device comprises a bladder and expanding the first expansion device comprises inflating the bladder.

8. The method of claim **1**, wherein imparting the force to the first flange comprises forming the first flange having a bend radius that is less than about 10 inches.

9. The method of claim **8**, wherein forming the first flange having a bend radius that is less than about 10 inches comprises bending the second composite material on a curvilinear end of the pressure element.

10. The method of claim **1**, further comprising moving the forming element and the pressure element along the mandrel and confining a second expansion device coupled to the second composite material.

11. The method of claim **10**, further comprising expanding the second expansion device to impart a force to the second composite material to move the second composite material away from the composite structure to facilitate forming a second flange.

12. The method of claim **1**, wherein the composite structure comprises a first layer of fibers, a second layer of fibers, and a honeycomb structure between the first and second layers of fibers.

13. The method of claim **12**, wherein the first composite material comprises a first plurality of fibers coupled to the composite structure on a first side opposite the space and the second composite material comprises a second plurality of fibers coupled to the composite structure on a second side adjacent the space.

14. The method of claim **13**, wherein the second plurality of fibers is larger than the first plurality of fibers.

15. The method of claim **14**, wherein a thickness of the second composite material is greater than a thickness of the first composite material.

16. The method of claim **13**, wherein the first plurality of fibers are formed of a different material than the second plurality of fibers.

17. The method of claim **1**, wherein the first and second composite material comprise a matrix material and a reinforcement material.

18. The method of claim **17**, wherein the matrix material comprises polyester resin, acrylic resin, vinyl ester resin, epoxy resin, polyurethane resin, phenolic resin, polyamide resin, and/or mixtures thereof.

19. The method of claim **17**, wherein the reinforcement material comprises glass fiber, graphite fiber, carbon fiber, ceramic fiber, aromatic polyamide fiber, and/or mixtures thereof.

20. The method of claim **1**, wherein the composite structure extends away from the mandrel toward the space.

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